The Puget Sound Nearshore Ecosystem Restoration Project: An Approach to Restoring Nearshore Ecosystems at a Sound-wide Scale.

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Given our emerging understanding that the health of Puget Sound is threatened by a diverse array of anthropogenic stressors operating across a wide range of spatial scales, it is essential that we develop a comprehensive restoration approach to guide actions from local to regional scales. The mission of the Puget Sound Nearshore Ecosystem Restoration Project is to understand how human activities have impacted nearshore ecosystem processes, and develop a spatially-explicit, process-based, Sound-wide restoration plan to strategically restore those processes.

Fundamental to this approach is to focus restoration on nearshore processes that form and maintain ecosystem structure, which in turn provide valued functions such as habitat for fish, wildlife, and plants. This concept is central in the principles developed by the Nearshore Science Team (NST) of scientists convened to help guide PSNERP.

The NST has developed a conceptual model to aid
ɔgram. Our goal is to describe the state of knowledge about complex relationships linking the structure, processes and functions of Puget Sound nearshore ecosystems. The approach is based on the premise that restoring just the structure of the system without reconstituting the underlying ecosystem processes is scientifically unsound. Thus, emphasis is on processes ("how it works"), rather than structure ("how it looks") of nearshore ecosystems *per se*, and how processes and structure influence ecosystem functions.

The model incorporates: (1) nested architecture; (2) spatial and temporal scales; (3) landscape context; (4) explanation and prediction of change; (5) pathways to assess

consequences of ecosystem restoration; and (6) transferability to a computational model. These criteria suggested a model with five hierarchical levels: (1) spatial and landscape domain; (2) organization of linkages among ecosystem process and structure; (3) processes linking ecosystem elements; (4) change/action scenario submodels predicting responses to restoration actions; and (5) timeframe and variability across multiple temporal scales.

Working groups of NST members are exploring ways to evaluate what stressors have affected Puget Sound's nearshore over history and using the historical template of nearshore conditions to guide, but not necessarily define restoration. Historical and present conditions of nearshore resources reveal which natural processes determine landscape structure and how well those processes still function. This largely physical science analysis will quantify change from various mapped representations of the nearshore at different times in history and apply a standardized typology of physical shoreforms as manifestations of various physical and ecological processes at different scales.

The product will be a series of transition matrices, which describe and quantify changes. This will further serve as inputs for a broader physical and social science exercise of determining likely and feasible restoration future scenarios for Puget Sound. A pilot change analysis is currently being conducted on portions of the central Puget Sound nearshore. From this pilot, the NST will be able to refine protocols for larger geographic areas of the sound.

Applying our understanding of how human activities have changed nearshore ecosystem processes will inform our hypotheses about appropriate restoration responses. We may predict or forecast from the conceptual model, alternative futures after restoration at various scales. Our restoration plan is being organized by a series of guiding restoration principles that describe our understanding of the nearshore and what range of actions or "management measures" are recommended to guide our approach to process-based restoration.

Nearshore processes that form and maintain ecosystem structure are expected to, in turn, provide valued functions such as habitat for fish, wildlife, and plants at a much greater geographic scale than structural or "site-based" restoration projects. We are applying a restoration concept that uses "portfolios" of actions that will guide restoration from small spatial scales of action (small coastal streams) to large "reaches" of the Puget Sound nearshore. Together, the assessments, principles, and forecasts will be used to develop a spatially explicit, process-based, Sound-wide restoration plan to strategically restore nearshore processes.

Following the PSNERP approach, adaptive management is woven throughout. In concept, the bright promise of adaptive management would appear to be an increasingly pervasive component of Puget Sound nearshore restoration; in reality, application of the more rigorous principles of adaptive management has so far been missing from most

restoration approaches. We are neither evaluating the functionality of restoration, improving the function of faltering restoration or even building a better understanding of what works and what doesn't work. Uncertainties associated with the technical and scientific backbone required to restore nearshore ecosystems demands the experimental essence of adaptive management.

It is unrealistic to expect opportunity-based restoration to be designed as scientifically rigorous experiments that can be modified or reversed to test alternative restoration hypotheses in the face of initial contrary results. Posing restoration projects as "experiments" testing the hypotheses suggested by the conceptual model, and monitoring the results, however, will allow us to adaptively mange PSNERP. We suggest that adaptive management in a comprehensive restoration program of Puget Sound nearshore ecosystems will have to be applied as dedicated demonstration 'testbed' experiments dedicated to resolving critical uncertainties upon which the success of this program hinges. Adaptive management principles should also be applied not only to program projects, but also across a wider range of restoration projects and programs currently ongoing.

Many questions are raised as we proceed in developing PSNERP. To organize these questions, a research plan is being developed that promotes scientific studies that will ultimately assist decision-makers protect and restore the nearshore ecosystem. Six research goals have been identified: 1) Understand nearshore ecosystem processes and linkages to watershed and marine systems; 2) Understand the effects of human activities on nearshore ecosystem processes; 3) Understand and predict the incremental and cumulative effects of restoration and preservation actions on nearshore ecosystems; 4) Understand the effects of social, cultural, and economic values on restoration and protection of the nearshore; 5) Understand the relationships of nearshore processes to important ecosystem functions such as support of human health and at-risk species; 6) Understand the roles of information--its representation, conceptualization, organization, and interpretation--related to nearshore ecosystem processes on the preservation and restoration potential of Puget Sound.

Priority research questions under each of these goals are being identified for immediate testing through ongoing "early-action" projects. By considering some of these questions, the restoration community in cooperation with PSNERP can develop appropriate monitoring and adaptive management strategies as integral parts of their restoration project and the outcomes of that monitoring will inform PSNERP. Still others reflect our sheer infancy in understanding certain complex systems and processes in the nearshore. These may require dedicated studies and demonstration or "proof of concept" projects.

To learn more about the Puget Sound Nearshore Partnership, the Puget Sound Nearshore Ecosystem Restoration Project and review technical documents of the Nearhshore Science Team, please visit our website at: www.pugetsoundnearshore.org